NTIP Draft Baseline System Design

NORTHERN TIER INTEROPERABILITY PROJECT

SOUTHWEST INTEROPERABILITY PROJECT

September 7, 2004

1   Executive Summary

The Northern Tier Interoperability Project (NTIP) provides many challenges for the design of a law enforcement radio system. The area spans over 550 miles, including the entire Montana-Canadian border. This region includes large expanses of relatively flat ranchland and farmland in the central and east, as well as the extremely mountainous terrain of the continental divide region in the western counties. Although most of the area is sparsely populated, there are several municipalities with significant population density. The Northern Tier Interoperability Project also encompasses four Indian tribal reservations and the Glacier National Park. These areas provide their own challenges due to the legal status of the Indian Nations and the environmental restrictions within the park.

The unique challenges of the Northern Tier area combined with the varying needs of the many state, local, tribal and federal agencies add additional complexity to the radio system design. Each of these users brings their own set of needs that when combined define the requirements of the system.

The NTIP system is designed to balance these requirements with the economic realities of the available funding. This system will provide voice and data radio services to the many member agencies, as well as insuring effective interoperability between these agencies. The project also includes the development of a digital interconnection and back-haul network to support this system and other public safety applications.

1.1 Voice Communications System Overview

The voice radio system is designed to meet the functional and coverage requirements of the many user agencies. The voice system is designed to support two primary types of user agencies.
- Local area users, who are generally the counties, municipalities, and tribal agencies.
- Wide area users, who are the state, and federal agencies.

The primary difference between these two user groups is their coverage requirements.
- The local agencies require thorough and reliable coverage in the area defined by their jurisdictional boundaries

- The wide area users require the ability to communicate across the entire Northern Tier area.

While both of these groups require the functionality provided by a modern digital voice radio communications system, not all users require every function. As an example, federal agencies require the highest level of encryption, while local and tribal users require a system that can be maintained affordably. These two groups of users drive a two-level design with a wide area system operating as an overlay to local systems in each county. The careful application of a variety of VHF P25-type system architectures accomplishes this goal without the compromises required by a one-size-fits-all approach.

Each of the agencies supported by the radio system will be provided with dispatch equipment to access the system for normal communications and for interoperable communications.

1.1.1 Wide Area System

The wide area systems users' needs will be met by a VHF P-25 multi-site linked trunked system. This system will provide primary service for the agencies that require wide area communications, and secondary communications for the local agencies that require service outside their normal coverage. Additionally, the wide area system will furnish the fundamental interoperability for which this program is chartered to provide.

This system will be made up of between 10 and 12, interconnected four-channel trunked radio sites. These sites will be strategically located to provide 95% reliable mobile coverage across the Northern Tier. The use of interconnected trunked radio sites will allow the users to automatically roam across the system without the need for user intervention. This removes the complexity typically associated with multi-site systems. The users will be able to communicate without having to know where the other users are located.

The specific number of trunked radio sites and the number of channels located at each site will be determined during the final design phase. It is not anticipated that the final design will vary greatly from these baseline assumptions.

The trunked system central control hardware will be located at a secure site with reliable interconnection to the radio transmitter and dispatch center sites. This equipment may be specific to the control needs of the NTIP system, or may be shared with other systems within the State, such as the Lewis & Clark County system.

1.1.2 <u>Local Area System</u>

The majority of local users (counties, municipalities, and Indian tribal reservations) will operate on conventional radio systems designed to provide the coverage and capacity required by those agencies. These systems, while architecturally similar, will be designed specifically to the requirements of each local area.

Each of the local systems will typically consist of a single site with 3 to 5 radio channels. These channels will be assigned to the law enforcement agencies responsible for the county and any municipalities or other agencies within the county. These channels, while not used in a trunked configuration will provide the full range of P-25 features, including unit ID, emergency call, and the ability to use secure communications.

FE recommends a different design approach for two areas' unique local coverage systems. The area of Flathead County (including Whitefish, Kalispell, and Big Fork), and the area of Hill County (including Havre) will be supported by multi-site trunked systems. These systems will operate as sub-systems of the wide area trunked network, providing a cost-effective solution to the unique communications requirements and challenges of these two counties.

1.2 Paging Overview

Many of the agencies of the NTIP Consortium use their existing analog voice radio systems to meet their requirements for paging and alerting. This functionality will continue to be a requirement for those agencies. Due to the evolution of the NTIP system from analog to digital technology, it becomes increasingly difficult to support traditional analog paging over voice radio systems. Since there are no paging systems available for the P25 digital radio systems, this requirement must be addressed in another manner. The proposed voice radio system is capable of multi-mode (P25 Digital and Analog) operation. While it is possible to continue using analog operation for paging, it will delay the systems conversion to fully digital operation.

The State is in the process of licensing a UHF frequency for paging operations state-wide. Currently the frequency is not coordinated within 75 miles of the Canadian border. This process may take a significant amount of time due to the unique FCC and international rules which apply in the border area.

FE recommends that the paging operations remain on the VHF system until the UHF channel is implemented. *FE* recommends that the NTIP Consortium work closely with the State to coordinate and license this frequency throughout the NTIP area. Once coordinated, the NTIP Consortium should proceed with the implementation of an independent paging system.

1.3 Data Communications System Overview

The NTIP Consortium's goals include the development of an interoperable wireless data system to support law enforcement. While the Needs Analysis did not indicate an urgent need for this capability, the use of mobile data communications is inevitable even in remote areas, as found in the Northern Tier region of Montana. Since the State is currently planning a statewide UHF mobile data network, *FE* recommends that the NTIP Consortium defer the immediate implementation of a data network. If the priorities change to the point where the data network is required prior to the statewide system becoming available, the P-25 voice system could be easily enhanced to provide short-term data network capabilities.

This approach will provide the consortium and the State considerable flexibility in addressing emergent issues, such as the changes that have occurred in wireless data communications technology since the SIEC standards were selected.

FE recommends that the final decision on this issue be made later in the NTIP program to allow a complete understanding of the data needs of each area and the trade-offs between various solutions.

1.4 Interconnection Network Overview

The Northern Tier Interoperability Project voice and data radio systems will rely on the creation of a consistent and reliable transport network to interconnect the many agencies and the supporting sites.

The Montana SIEC has selected digital microwave technology as the primary interconnection method for interoperable radio systems. While digital microwave does have many advantages in terms of interoperability and reliability, the expanse of the area to be covered combined with the challenges presented by the unique terrain and the special requirements within Glacier National Park make a microwave-only system less than optimum.

FE has considered the trade-offs between microwave and optical fiber or other terrestrial based leased links. This has lead to the recommendation that a hybrid system using a combination of technologies will best meet the needs of the NTIP systems.

1.5 Conclusions

FE's recommendations for the voice, data and interconnect systems combine to provide NTIP a system which will meet the goals Consortium and its member agencies. The combination of VHF P-25 trunked and conventional voice operation and interoperable data communications, supported by a consistent digital back-bone network insure that the many law enforcement agencies of the Northern Tier will be provided with interoperable communications throughout their area of responsibility.

This NTIP system will further, provide the basis of a statewide interconnected, interoperable communications infrastructure for Montana.

2 Voice System Design

The Northern Tier Interoperability Project (NTIP) provides unique challenges for the design of a law enforcement voice radio system. The area to be covered spans over the 550 miles of the Montana-Canadian border. This region includes large expanses of relatively flat ranchland and farmland in the central and eastern portions of the State, as well as the extremely mountainous terrain of the continental divide region in the western counties. Although most of the area is fairly sparsely populated, there are several areas with small municipalities. The Northern Tier Interoperability Project also encompasses several Indian tribal reservations and the Glacier National Park. These areas provide their own challenges due to the legal status of the Indian Nations and the environmental restrictions within the park.

2.1 System Overview

The unique challenges of the Northern Tier area combined with the needs of the various state, local, tribal and federal agencies add an additional layer of complexity to the voice radio system. Each of these users brings their own set of needs that combine to define the requirements of the system.

While all these agencies require the functionality provide by a modern digital voice radio communications system, there are some differences between agencies. The careful application of a variety of VHF P25-type system architectures allows for the customization of the network, to the users without the compromises required by a one-size-fits-all approach.

The system is best defined by grouping the requirements of the local area users separately from the requirements of the wide area users.

- Local area users are generally the counties, municipalities, and tribal agencies.
- Wide area users are the State, and federal agencies.

The primary difference between these two user groups is there coverage requirements.

- The local agencies require thorough and reliable coverage in the area defined by their jurisdictional boundaries
- The wide area users require the ability to communicate across the whole of the northern tier.

These two groups of users drive a two level design with a wide area system operating as an overlay to local systems in each county.

*FE'*s evaluation indicated that there are two areas within the Northern Tier that are best served by a slightly different design approach. These areas are the Flathead County area including Whitefish, Kalispell, and Big Fork, and the Hill County area including Havre. The design of the system to support these areas will be discussed in detail separate from the overall system.

2.2 Wide Area Trunked System Design

The wide area coverage needs are best met by a multi-site linked trunked system. This system will provide the primary means of communications for the agencies that require communications over the wide expenses of the Northern Tier, and secondary communications for the local agencies that may temporarily be outside the coverage of their local system. Additionally, the wide area system will furnish the fundamental interoperability for which this program is chartered to provide.

The system will be made up of 10 to 12 interconnected P-25 trunked radio system sites. The specific number of trunked radio sites will be determined during the final design phase. These sites will be strategically located to provide 95% reliable mobile coverage across the Northern Tier. The use of interconnected trunked radio sites will allow the users on this system to automatically roam across the system without the need of user intervention. The trunking system will provide a "Talk-Group" or virtual channel for each agency or operation using the system.

Each of these sites will be comprised of 4 VHF channels on the average. The specific number of channels located at each site will be determined during the final design phase. It is not anticipated that the final design will vary greatly from these baseline assumptions. The site design will include the fixed radio equipment, Antenna combining system, back up power system, and interface equipment to the interconnection network.

It is assumed that approximately one half of the sites will be able to be located at sites have existing tower and building facilities that can provide sufficient space and support for the proposed system. At the remaining sites it is proposed that the system will require a new facility including an equipment shelter, antenna tower and emergency generator. This assumption will be addressed as the sites are selected during the final design.

The trunked system central control hardware will need to be located at a secure site with reliable interconnection to the majority of radio transmitter and dispatch center sites. This equipment may be specific to the control needs of the NTIP system, or may be shared with other systems within the State. A cost-benefit analysis and a risk analysis will need to be done to determine the optimum solution. Due to the architectural differences between different vendors systems, these tasks can only be accomplished during the final design phase of the project. Diagram 1 provides an overall view of the proposed system concept. Diagram 2 provides additional detail on the proposed site equipment. This conceptual design will be refined dependent on the specific system implemented.

Diagram 1

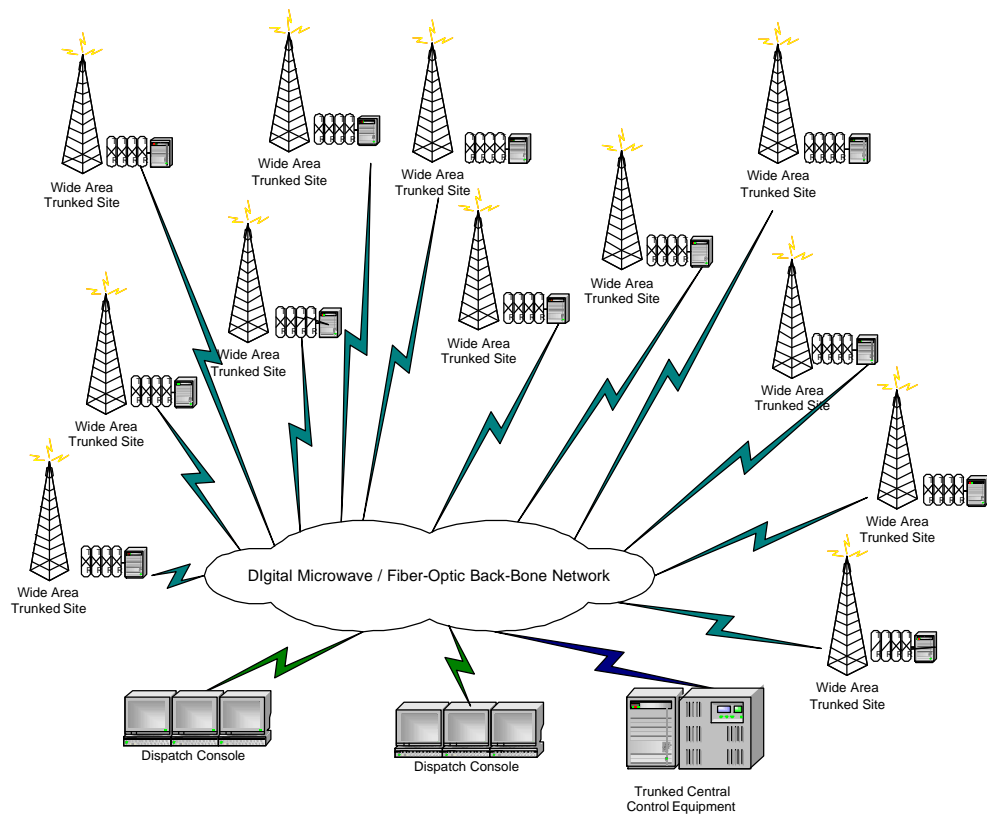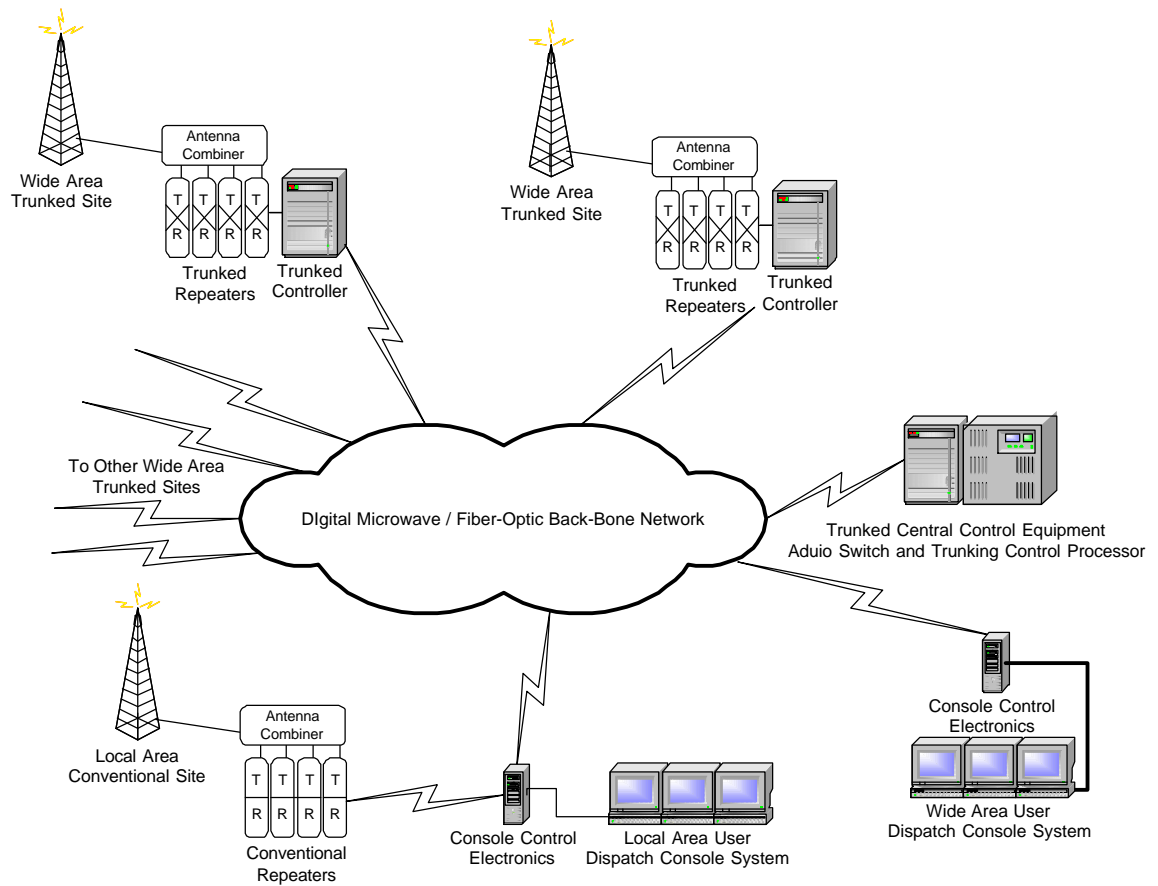**Diagram 2**

2.3 Local Area (County Coverage) Design

The majority of local user agencies; counties, municipalities, and Indian tribal reservations, will operate on conventional radio systems designed to provide the coverage and capacity required by those agencies. Each of these systems, while architecturally similar, will be specifically designed to the needs of the particular local area.

The architecture applied to the design of the local systems will consist of a single site with 3 to 5 VHF P-25 radio channels. These channels will be assigned to the law enforcement agencies responsible for the County and any municipalities or other agencies within the County.

Each of the agencies supported by this radio site will be provided with dispatch equipment to control the channels located at this site. These dispatch systems will also provide access to the wide area system for interoperability and out of jurisdiction coverage.

The local area system design concept is shown in Diagram 3. The design of these systems will be refined to address the specific issues of each local coverage area in the final design phase.
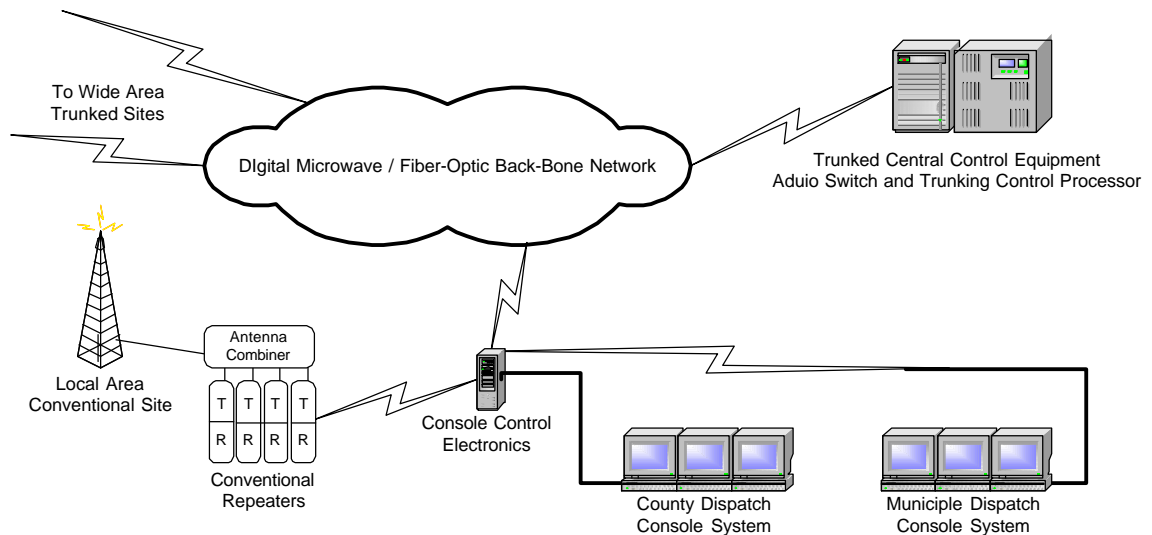

Diagram 3

2.3.1 <u>Tribal Systems</u>

The tribal reservations will be supported by the local system. In most cases, the tribal agencies will operate similar to a municipality within the local county system. The tribal law enforcement agencies will be provided an appropriate number of channels on the system that provides the most appropriate coverage of their jurisdiction. In some cases due to coverage or capacity issues, particular tribal reservations may require their own radio site.

Each tribal law enforcement agency will be provided with the dispatch equipment required to access these channels, as well as the other local channels and the wide area system for interoperability and off reservation coverage.

2.3.2 Flathead County Area Design

The design of a radio system for the Flathead County area provides a number of challenges that are significantly different from the majority of the Northern Tier. The deep canyons and many pockets of residential and commercial population create the situation where no single radio site can provide anywhere near the required coverage in even a small number of the populated areas of the county.

The many canyons and mountains within Flathead County dictate that a multi-site interconnected radio system will be required to insure that the necessary coverage will exist throughout the county.

The many different agencies supporting the County and municipalities require a level of flexibility beyond that available with a conventional system. For this reason a trunked system is most appropriate to insure that each agency has the functionality they require. The combination of multi-site interconnected design and trunked operation insures that the local system in Flathead County will meet the needs of all the user agencies.

The preliminary investigation conducted by *FE* indicate that it will require between 3 and 5 radio sites to provide the Flathead County area with an acceptable level of coverage. The number and location of radio sites will be the determined during the final design phase. These sites will be tightly integrated with the wide area trunked system to simplify operation and maximize the use of shared resources, insuring the most efficient use of the limited resources available.

The trunked system central control hardware for this system will be integrated with the control hardware for the wide area coverage system. As such, the analysis and selection will be accomplished during the final design phase of the project.

2.3.3 <u>Hill County Area Design</u>

The design of a radio system for the Hill County area provides its own set of challenges different from the Flathead County area. The size of population and the fact that a number of federal agencies have operations in the area greatly increase the requirements for local area communications.

This collection of different agencies require a level of flexibility beyond that available with a conventional system. For this reason **FE** has determined that a trunked system is most appropriate to insure that each agency has the functionality they require.

The coverage requirements for several of these agencies extend significantly beyond the County. For that reason more than one trunked site may be required. **FE** estimates that 2 to 3 sites will be required.   The number and location of radio sites will be the determined during the final design phase. These sites will be tightly integrated with the wide area trunked system to simplify operation and maximize the use of shared resources, insuring the most efficient use of the limited resources available

As in Flathead County, the combination of multi-site interconnected design and trunked operation will insure that the system in Hill County will meet the needs of all the user agencies.

As with the Flathead County system, the trunked system central control hardware for this system will be integrated with the control hardware for the wide area coverage system. As such, the analysis and selection will be accomplished during the final design phase of the project.

2.4 Paging Support

The law enforcement agencies that make up the NTIP Consortium currently use their existing analog voice radio systems to support the transmission of paging and alerting signals. This functionality continues to be a requirement for the NTIP agencies. Due to the evolution of the NTIP system from analog to digital technology, it is becoming increasingly difficult to support traditional analog paging over voice radio systems.

At the present time there are no paging systems available for the P25 digital radio systems. The voice system being proposed is capable of multi-mode (P25 Digital and Analog) operation. While it is possible to continue using analog operation for paging, it will prevent the system from being converted to fully digital operation.

The State has licensed a UHF frequency for statewide paging operations. Currently the frequency is not coordinated within 75 miles from the Canadian border. This area is termed "above line A" by the FCC due to the unique FCC and international rules which apply in the area. **FE** recommends that the NTIP Consortium work closely with the State to coordinate and license this frequency throughout the NTIP region. Unfortunately, this process has historically taken a significant amount of time. For this reason, **FE** is recommending that paging operations remain on the VHF voice system in the short-term.

Once the new frequency is coordinated, **FE** recommends that the NTIP Consortium proceed with the implementation of a UHF paging system throughout the region. This will allow the migration of paging and alerting from the VHF dispatch frequencies to the new UHF paging frequency allowing the transition of the VHF system to complete digital operation.

3 Data System Design

The Northern Tier Interoperability Project (NTIP) charter and goals include the creation of an interoperable wireless data system to support law enforcement. While the Needs Analysis did not indicate an urgent need for this capability, the use of mobile data communications is inevitable even in remote areas, as found in the Northern Tier region of Montana. With database access and digital information sharing becoming significantly more important, the design of any interoperable radio system should include data communications support to maximize effectiveness.

FE has evaluated the standards and plans which have been put in place by the Montana SIEC, as well as the developments in wireless data technology that have occurred since these standards and plans were created. The most appropriate wireless data technologies for inclusion in the NTIP system are;

- The enhancement of the VHF P25 voice radio system to transport data.
- The deployment of a UHF dedicated data system

These two design concepts are discussed in detail below.

3.1 Project 25 Data Overlay System Design

The Project 25 standards based technology that is being implemented to support voice communications throughout the Northern Tier can easily be upgraded to support data communications. Given the expanse of the area to be covered, the minimal current data requirements and the relatively insignificant cost of adding the data capability to the voice system, *FE* recommends the use of this approach to supply data service in areas where other data services are not available.

The design concept recommended by *FE* is to implement data capabilities on one of the VHF voice system channels in each coverage area requiring data communications. Further study may indicate that additional channels need also to be equipped. The number and location of the necessary data equipped channels will depend on the data traffic loading expected in each area and the particular agencies that intend to make use of the data capabilities. Diagram 4 depicts a typical shared voice and data P-25 system. The specific layout of the data overlay for the NTIP system will need to be refined after the selection of the vendor. This is due to the differences in the architecture of the data portion of a P-25 system between the various solutions on the market.
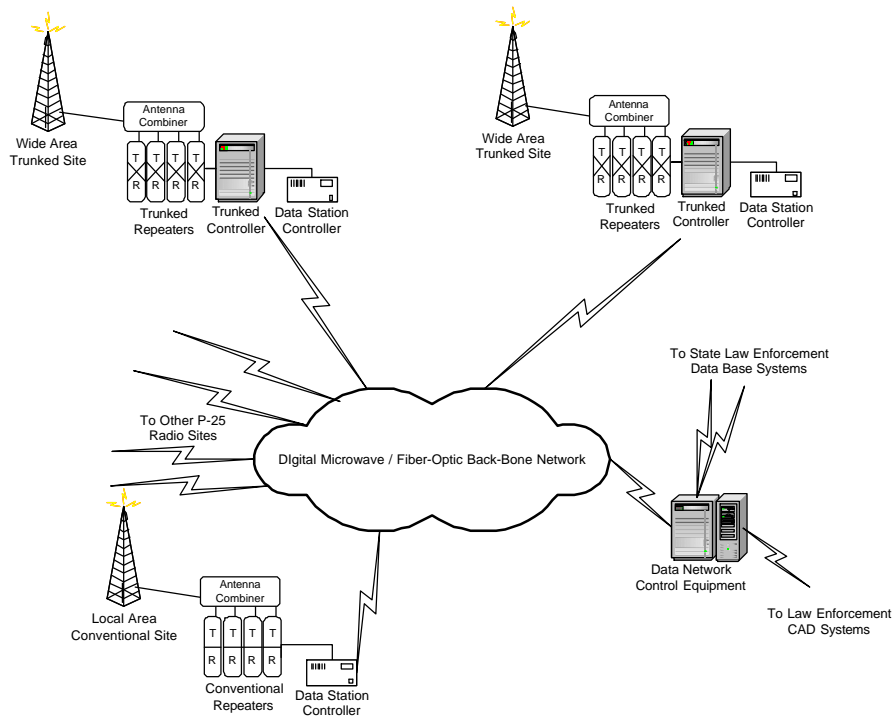

Diagram 4

The combination of voice and data communications on the same channels does have some drawbacks. The amount of data traffic must be carefully evaluated to prevent the situation where voice and data traffic are in significant contention for radio channel resources. In addition, the shared use of the same radio equipment can add some complexity for the user. Neither of these issues is insurmountable.

3.2 UHF Data Channel Design

The State of Montana Statewide Interoperability Executive Council (SIEC) has set a standard for Public Safety data communications. This standard was set to provide a level of interoperability across the State.   The standard selected calls for the use of the Motorola DataTAC system on the UHF radio band. A significant investment has already been made in this technology in other areas of the State.

FE recommends that the expansion of this system be evaluated carefully. The DataTAC technology has been superseded with newer, higher speed systems. The advantage of leveraging the existing equipment investment must be balanced against the advantages of implementing these newer, improved technologies in the NTIP and future systems.

Diagram 5 depicts a typical mobile data network.   Depending on the technology selected, the specific components may vary, however the overall architecture will remain similar to that pictured.
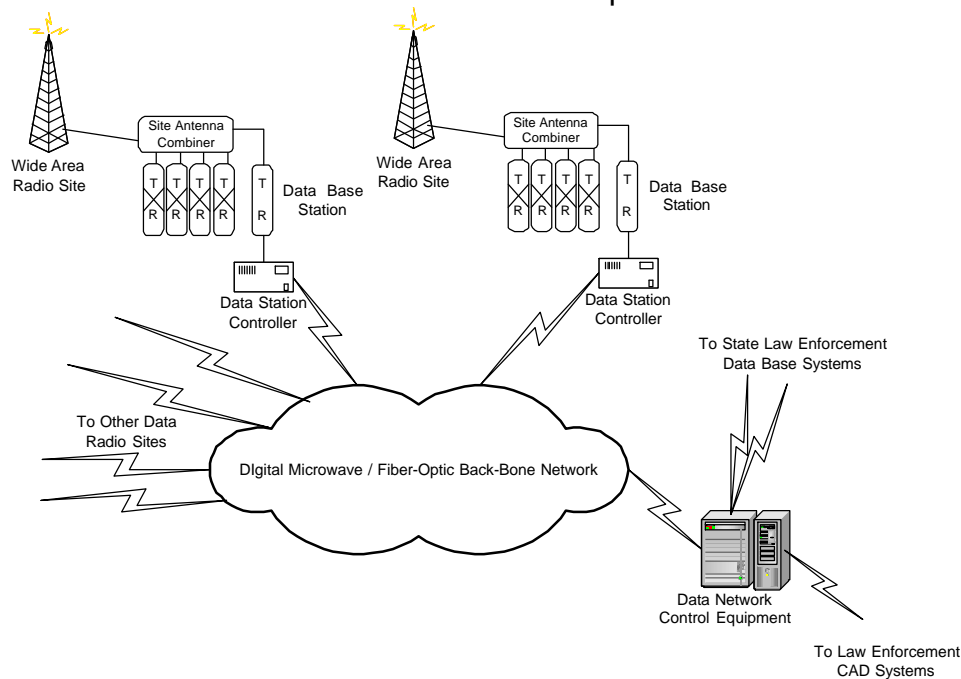

Diagram 5

3.3 Data System Recommendations

Due to the rapid evolution occurring in the wireless data communications field and the fact that the State of Montana is currently planning a statewide UHF mobile data network, *FE* recommends that the NTIP Consortium defer the immediate implementation of any data network.

If the implementation of a data system is required, *FE* is recommending a phased approach. The first phase would be to make use of the data capabilities of the planned VHF Project 25 voice radio system in areas where data services are required immediately. The second phase would be the implementation of a dedicated UHF data system. To this end, *FE* recommends the continued investigation into the most appropriate dedicated data technology.

This approach to the NTIP data system deployment will provide the consortium and the State a valuable level of flexibility in addressing emergent issues, such as the changes that have occurred in wireless data communications technology since the SIEC standards were selected.

As the system design is refined, each area will need to evaluate their data requirements to drive a final decision on the implementation of a P-25 data system, or a dedicated UHF data system.

FE recommends that the final decision on this issue be made later in the NTIP program to allow a complete understanding of the data needs of each area and the trade-offs between various solutions.

4 Network Interconnection Design

The Northern Tier Interoperability Project (NTIP) voice and data radio systems will rely on the creation of a consistent and reliable transport network to interconnect the many agencies and the supporting sites. This network will be based on the technologies and standards set by the SIEC.

The SIEC has selected digital microwave technology as the primary interconnect method for interoperable radio systems throughout the State of Montana. While digital microwave does have many advantages in terms of interoperability and reliability, the expanse of the area to be covered combined with the challenges

presented by the unique terrain and the special requirements within Glacier National Park make a microwave only system less than optimum.

FE has considered the trade-offs between microwave and optical fiber or other terrestrial based leased links. This has lead to the recommendation that a hybrid system using a combination of technologies will best meet the needs of the NTIP systems.

4.1 System Overview

The interconnection design being recommendation for the NTIP system will consist of a hybrid of digital microwave links and leased digital optical fiber and other terrestrial links. The adherence to industry T-Carrier standards will allow the seamless interconnection of these technologies without the loss of reliability or functionality provided by the digital microwave technology recommended in the SIEC standards plan.

The system will make use of digital microwave for many of the links to the radio sites and for added reliability where the terrestrial link can not be assured to meet the requirements of the system.

Leased digital optical fiber and other terrestrial links will be used to interconnect otherwise independent microwave sections to form a consistent backbone across the Northern Tier.

Diagram 6 provides an overview of the structure of the proposed interconnection system.
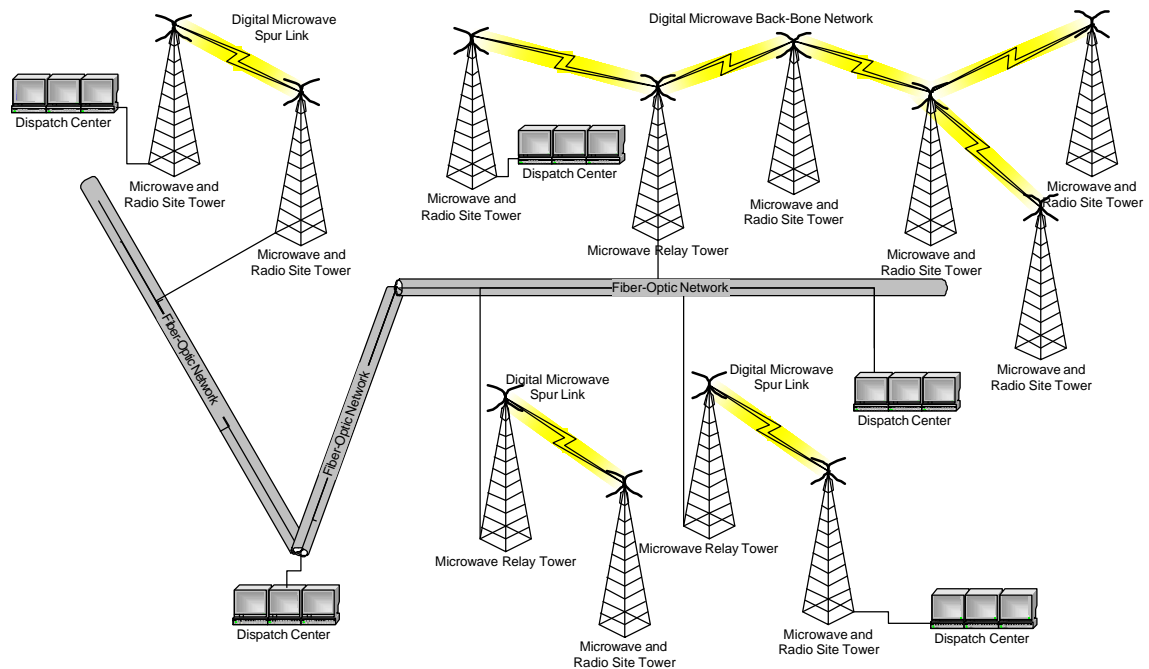
Diagram 6

4.2 Digital Microwave System Design

Digital microwave will be used to the greatest extent practical. In general digital microwave will be implemented for three distinct purposes. Where practical, sections of the primary backbone interconnection system will be constructed with multiple links of digital microwave between sites owned or controlled by NTIP or state agencies. Second, digital microwave spur links will be implemented to provide access from the primary backbone system to radio sites and dispatch centers that are not located directly on the network. Third, digital microwave may be implemented as a redundant connection for critical links and where a secondary network connection is required for back-up, such as the National Guard armories.

The exact capacity and routing of the digital microwave paths will be determined during the final system design phase. At this time it is anticipated that each digital microwave link will have a minimum capacity of a single DS-3. In many cases specific microwave links will require multiple DS-3 or up to OC-3 capacity.

All digital microwave sites will be designed to the standards for public safety, mission critical application. This includes having the sites equipped with redundant power sources and fuel supplies capable of insuring continuous operation independent of utility power for the longest outage expected. These sites will also be equipped with maintenance and security alarm systems to allow for continuous monitoring of all vital equipment and facilities.

4.3 Leased Link Interconnection Issues

The use of public/shared network links within a public safely system must be carefully evaluated. While these network connections are often much more cost effective, and at times can provide service in areas where private microwave systems are impractical, they bring with them concerns of reliability and ongoing operating costs.

Today's public network is carried primarily by digital optical fiber links. While this technology is extremely reliable, the nature of a terrestrial based public shared system does create several areas for concern.

First, since the optical fiber or other cable must remain unbroken between hubs and/or nodes, it is critical that the "outside plant" infrastructure not be susceptible to damage or interruption. While it is possible to run these cables by many methods, *FE* is only recommending the use of these links where it can be assured that the cable is run underground. These runs are not immune to outage, but have a much lower incident rate since they are typically not affected by weather and other above ground events (i.e. auto accidents affecting utility poles, etc.)

To insure that above-ground cable paths are not used for critical links, digital microwave spur links may be required to connect certain leased link access locations to system equipment locations, such as dispatch centers, radio sites, and the National Guard armories. These digital microwave spurs will provide high reliability links between the leased access points and the system equipment locations. The access points will be selected to insure the highest reliability by avoiding links that rely on above ground cable infrastructure.

The second opportunity for potential reliability issues is due to the reliance on equipment and power not under the control of the public safety agency or the State. Any event that can interrupt power to a hub or node will interrupt communications. For this reason, *FE* recommends that extensive discussions be undertaken with any digital line or optical fiber line supplier to thoroughly understand the susceptibility of their network, and to rely on paths and routings that only operate though hubs and nodes that are provided with back-up power and redundant electronics.

FE's recommendation to implement a hybrid digital microwave and leased digital terrestrial cable backbone system is contingent on these two issues being properly addressed during the final system design.

5 Summary of Recommendations

FE's recommendations for the NTIP system consist of the following;

1. A multi-site trunked VHF P-25 trunked system to support wide area communications.
2. VHF conventional P-25 systems to support local (County) communications.
3. Deferred deployment of data services where practical, P-25 data communications initially, migrating to a dedicated UHF data system in later phases.
4. A hybrid digital microwave and leased digital terrestrial cable interconnect back-bone network.

These components combine to provide NTIP a system which will meet the goals of the Consortium and its member agencies.

This combination of P-25 trunked and conventional voice operation and interoperable data communications, supported by a consistent digital back-bone network insure that the many law enforcement agencies of the Northern Tier will be provided with interoperable communications throughout their areas of responsibility. This NTIP system will further, provide the basis of a statewide interconnected, interoperable communications infrastructure for Montana.